

Cryogenic Fluid Management Technology and Nuclear Thermal Propulsion

Brian D. Taylor^{1a}, Jarvis Caffrey², Ali Hedayat^{1a}, Jonathan Stephens^{1b}, Robert Polsgrove^{1a}

^{1a}*Main Propulsion Systems Branch and ^{1b}Propulsion Research and Technology Branch, NASA Marshall Space Flight Center, Huntsville, AL 35812*

²*Department of Nuclear Engineering and Radiation Health Physics, Oregon State University, Corvallis, OR, 97331*

Abstract. Cryogenic fluid management (CFM) is critical to the success of future nuclear thermal propulsion powered vehicles. While this is an issue for any propulsion system utilizing cryogenic propellants, this is made more challenging by the radiation flux produced by the reactor in a nuclear thermal rocket (NTR). Managing the cryogenic fuel to prevent propellant loss to boil off and leakage is needed to limit the required quantity of propellant to a reasonable level. Analysis shows deposition of energy into liquid hydrogen fuel tanks in the vicinity of the nuclear thermal engine. This is on top of ambient environment sources of heat. Investments in cryogenic/thermal management systems (some of which are ongoing at various organizations) are needed in parallel to nuclear thermal engine development in order to one day see the successful operation of an entire stage. High durability, low thermal conductivity insulation is one developmental need. Light weight cryocoolers capable of removing heat from large fluid volumes at temperatures as low as ~20 K are needed to remove heat leak from the propellant of an NTR. Valve leakage is an additional CFM issue of great importance. Leakage rates of state of the art, launch vehicle size valves (which is approximately the size valves needed for a Mars transfer vehicle) are quite high and would result in large quantities of lost propellant over a long duration mission. Additionally, the liquid acquisition system inside the propellant tank must deliver properly conditioned propellant to the feed line for successful engine operation and avoid intake of warm or gaseous propellant. Analysis of the thermal environment and the CFM technology development are discussed in the accompanying presentation.

Keywords: Nuclear, Cryogenic, Propellant, Management, Radiation